Dec. 26, 1950 P. L. WIGTON 2,535,109

DRYING APPARATUS

Filed Sept. 5, 1944 2 Sheets-Sheet 1

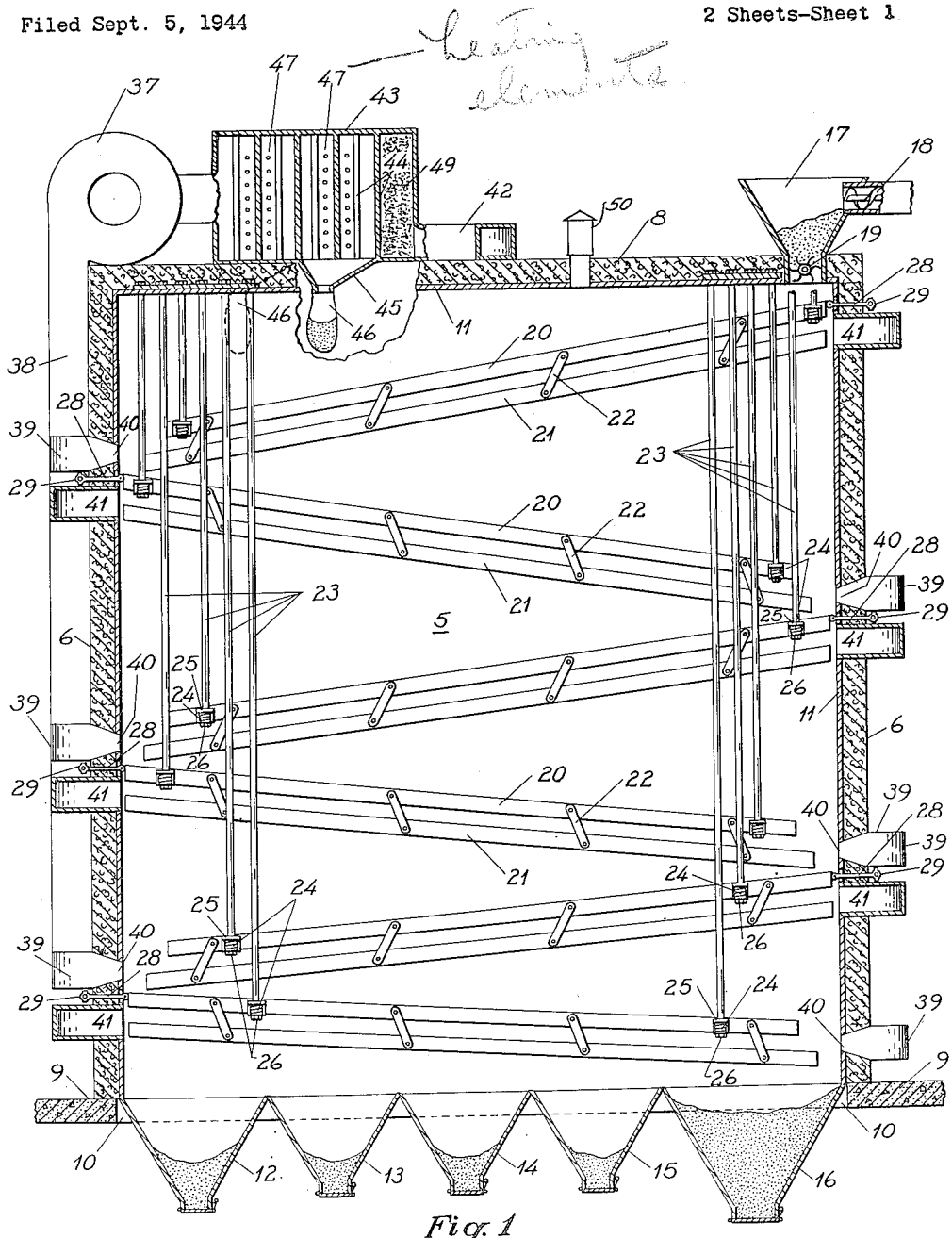


Fig. 1

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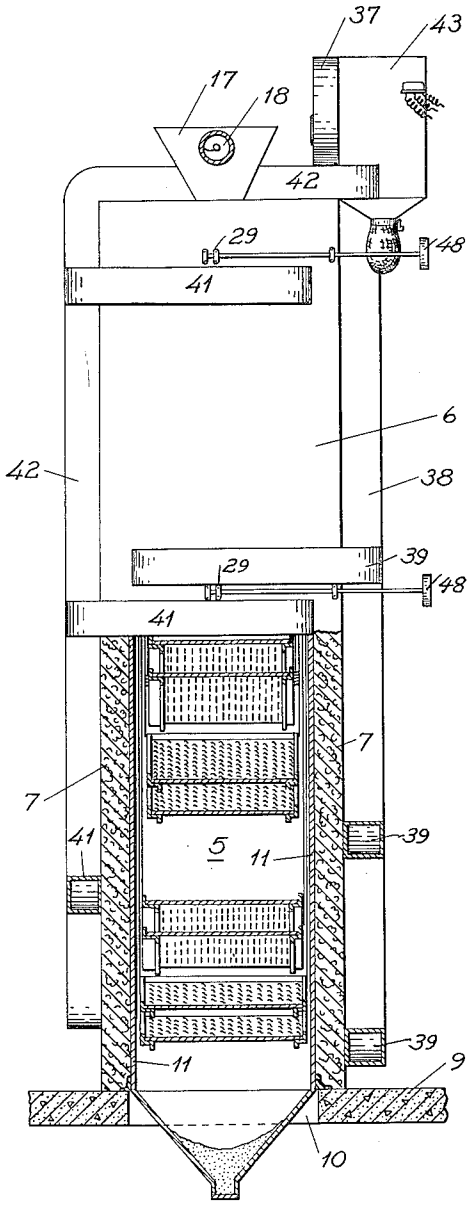


Fig. 2

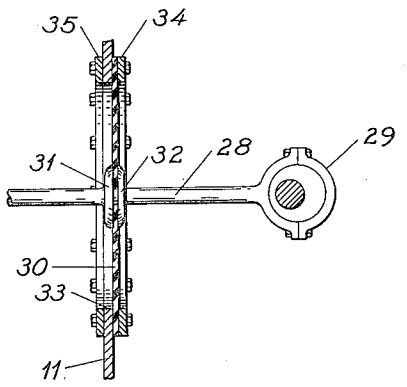


Fig. 3

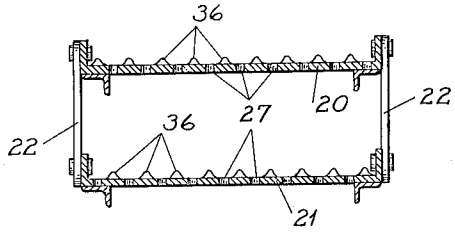


Fig. 4

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2,535,109

DRYING APPARATUS

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Application September 5, 1944, Serial No. 552,729

12 Claims. (Cl. 209—3)

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My invention relates to drying apparatus and particularly to apparatus for drying materials such as crushed or powdered minerals and the like.

In many industrial operations, such as ore beneficiation, or in the refining of chemical salts, for example, a body of solids in granular or finely divided condition is first dewatered as in filters, centrifuges or the like, and is then passed to a final drying stage to condition it for shipment, market, or some further treatment requiring a dry state.

It has been customary to perform these drying operations in rotary, kiln driers, and the apparatus of the present invention has many advantageous features from the user's standpoint, compared with kiln driers. Thus, the apparatus of the present invention is less expensive in first cost and requires a lesser amount of repairs and replacement in continuous operation.

Secondly, the apparatus of the present invention is less heavy and cumbersome, and occupies a considerably lesser amount of floor space with reference to its treatment capacity. It is also less expensive to operate both with respect to power consumption, and fuel consumption for the heating action.

In the third place, the apparatus of the present invention is more efficient in reducing the possibility that some of the charge may be retained too long and become overheated while another portion may be discharged too rapidly and be imperfectly dried.

It is thus an object of my invention to provide an improved drying apparatus providing the above and is also of simple and inexpensive construction.

It is another object of my invention to provide an improved drying apparatus of the closed or sealed type suitable for continuous operation and affording ready removal of dried material without interruption of the drying operation.

Further objects and advantages of my invention will be apparent from the following description and the features of novelty which characterize my invention will be pointed out in the appended claims.

For a better understanding of my invention reference may be had to the accompanying drawings in which—

Fig. 1 is a side elevation view, partly in section of a drying apparatus embodying my invention;

Fig. 2 is an end vew, partly in section of the apparatus shown in Fig. 1;

Fig. 3 is an enlarged detail view of one of the vibrators employed in the apparatus; and

Fig. 4 is an enlarged sectional view of a pair of the conveyors employed in the drying apparatus.

Briefly the apparatus illustrated in the drawings comprises a rectangular upright chamber having rigid walls constructed of reinforced concrete or other suitable material. Within the

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chamber and supported on hangers secured to the top wall are arranged a plurality of pairs of downwardly inclined parallel conveyors or tables. The several pairs are arranged in zigzag disposition so that material to be dried and which is introduced at the top is conducted downwardly and progressively from one end to the other of the chamber. As clearly shown in Fig. 1, air is withdrawn from the chamber, is heated, and then returned through nozzles directed between the conveyors of each pair at the lower end, the air thereby passing upwardly along the conveyors. Vibrators are provided to shake the conveyors and facilitate the movement of material. The dried material is collected in hoppers at the bottom of the chamber and may be removed as desired. The chamber is maintained sealed throughout its operation to minimize the escape of vapors, gases or dust, and any particles of material withdrawn with the air are separated from the air before its return to the chamber. Accumulated moisture is removed from the air, and, if desired, a pressure relief valve may be provided to prevent any accumulation of excessive pressures within the chamber.

As shown in Figs. 1 and 2 the drying apparatus comprises a chamber 5 formed within a housing having end walls 6, side walls 7, and a top wall 8 all joined together and supported on a floor 9 about an opening 10 in the floor. The chamber is provided with a lining 11 of sheet steel or other suitable material, and a plurality of hoppers 12, 13, 14, 15, and 16 are supported from the liner 11 and extend through the opening 10. While not illustrated, suitable doors are provided in the walls of the chamber to provide access to the interior for inspection, cleaning and repair of the apparatus.

A supply hopper 17 is supported on the top wall 8 and material to be dried is conducted to this hopper by a suitable feeding device such as a screw-conveyor 18 driven by a suitable motor (not shown). The material enters the chamber 5 from the hopper 17 upon rotation of a star or rotary valve feeder 19 also driven by a motor not shown.

In order to conduct the material through the chamber during the drying process I provide a plurality of pairs of conveyors each comprising a top conveyor 20 and a bottom conveyor 21 secured together in parallel relation by a plurality of straps 22. The several pairs of conveyors may be secured within the chamber on any suitable supports or hangers and have been shown as suspended from the top wall 8 on rods 23, the lengths of the rods being selected so that the pairs of conveyors are supported in zigzag disposition and inclined downwardly so that the material may be conducted downwardly and progressively from one end of the chamber 5 to the other. The lower end of each pair of conveyors is spaced from the end wall 6 and is arranged so that the

material discharged therefrom falls on the upper end of the next lower conveyor. The conveyors are resiliently supported on the lower ends of the rods 23 by means of springs 24 which are held under compression between brackets 25 on the conveyors and heads 26 at the lower ends of the rods.

Each of the conveyors is an elongated flat rectangular plate or table of channel shaped cross section and provided with a multiplicity of holes or perforations as indicated at 27 in Fig. 4. These holes permit particles of material of a predetermined size to fall through the conveyors as they are dried and facilitate rapid drying. Because wet material is more difficult to move down the conveyors than dry material, the slopes of the upper conveyors are steepest and successively lower conveyors are made less steep. The wet material thus starts at the top where it falls from the hopper 17 onto the higher end of the top conveyor; the steep incline of the top pair of conveyors facilitates the downward movement of the wet material; then, as the material becomes drier the slope is less steep so that the downward rate of flow of the material is substantially uniform.

The downward movement of the material is induced primarily by shaking or vibrating the conveyors to agitate the material thereon. Each of the top conveyors 20 of each pair is connected by a link 28 to an eccentric vibrator 29 outside the chamber 5. As shown in the enlarged view of Fig. 3, the link 28 is mounted in a diaphragm or seal 30 which may be constructed of any suitable material such as rubber, leather, flexible metal, or the like. The diaphragm 30 is sealed to the link 28 between shoulders 31 and 32, and is clamped and sealed about an opening 33 in the liner 11 by a ring 34 which is bolted to the wall 11, an inner ring 35 may be provided to further strengthen the wall about the vibrating mechanism. The diaphragm permits reciprocating movement of the link without leakage of air or gas through the chamber walls. The links are suitably hinged to the conveyors 20 and rapidly vibrate the conveyors to induce steady downward movement of the material to be dried.

In order to minimize stratification of the material and to maintain the moving body of material loose, I provide a multiplicity of upwardly extending sharp, pointed projections 36 arranged in staggered relation with respect to said perforations over the top surface of each of the conveyors. Since the wet material tends to cake up as it is dried, these projections act to break up and agitate the material when the conveyors are vibrated and some of the material is worked through the holes 27 and falls on the next lower surface. The holes 27 may be graduated in size, if desirable. For example, the holes may be made smaller in successively lower pairs of conveyors so that the particles of dried material reaching the bottom conveyor must be of a predetermined small size before they can drop through to the hoppers 12, 13, 14, and 15; any larger pieces are thus conveyed to the end of the bottom conveyor and collect in the last hopper 16. The hopper 16 is larger than the other hoppers in order to receive the larger quantities of material, at the end of the process: the hopper 12 at the other end of the chamber is also made larger than the intermediate hoppers 13, 14, and 15 because more of the dried material tends to fall at the ends of the conveyors than falls along the intermediate portions.

In order to heat the air in the chamber and to dry the material on the conveyors any suitable

air circulating and drying apparatus may be provided. I prefer to employ the arrangement shown on the drawings which comprises a closed air circulating system and heating devices arranged to heat air withdrawn from the chamber before it is returned thereto. The air circulating apparatus includes a fan or blower 37 mounted on top of the wall 8 outside the chamber and arranged to blow air downwardly through a distributing conduit or duct 38, and into the chamber 5 through branch ducts 39 terminating in nozzles 40 at the entrance to the chamber. The air supplied to the blower is withdrawn from the chamber 5 through outlet ducts 41 which are branches of a return duct 42 which conveys the air to a heating chamber within a casing 43 on top of the wall 8 adjacent the blower 37. The casing 43 is provided with a plurality of baffles 44 to direct the air in a zigzag or tortuous path from one side of the casing to the other. Dust or fine material carried by the air is separated from the air by the centrifugal action and turbulence produced by the baffles and falls to the bottom of the casing 43 where hoppers or funnels 45 catch the material and direct it into suitable bags 46. The air is heated during its passage through the casing 43 by suitable heating elements 47 arranged within the passages formed by the baffles 44. The heated air discharged from the nozzles 40 is directed at relatively high velocities between the top conveyor 20 and the bottom conveyor 21 of each pair, and tends to circulate upwardly between the conveyors to the outlets 41. The hottest air is thus directed along the conveyors where it is most effective for drying the material on the conveyors.

During the operation of the drying apparatus crushed mineral for example, is supplied continuously to the topmost conveyor 20 through the hopper 17 by operation of the screw conveyor 18 and the star feeder 19. The blower 37 is driven by a suitable motor (not shown) and circulates air continuously through the nozzles 40 and along the conveyors. The conveyors are vibrated continuously by operation of the eccentrics 29 also driven by suitable prime movers (not shown) through driving mechanism such as pulleys 48. As the mineral moves downwardly along the conveyors and through the holes 27 therein it becomes progressively dryer and finally reaches the bottom of the chamber suitably dried. The dried mineral collects in the hoppers 12, 13, 14, 15, and 16 at the bottom of the chamber and may be removed as desired through removable bottom doors which are provided on the hoppers. Some dust and particles of mineral are unavoidably drawn into the air circulating system through the return ducts 41 and this mineral is separated from the air in the casing 43 and collects in the bags 46 which may be removed from the funnels 45 and emptied. The chamber is maintained closed throughout the operation and escape of gases and dust is effectively prevented. Few wearing parts are located within the chamber, the agitating eccentrics being located outside the sealed chamber.

In the beginning of operation, it will usually be unnecessary to make provision for removal of moisture from the system. However, as the operation proceeds and moisture accumulates in the circulating air streams, provision from moisture removal must be made. This is conveniently done by placing porous adsorbent filtering media 49 at the intake of heating chamber 43, which will collect excess moisture, and by periodic re-

placement of the filter media, such moisture is effectively removed from the system.

Since heating of the air during the beginning of the operation will cause an increase of pressure in this closed system, a pressure relief valve **50** is provided in the top wall **8** of the chamber **5**. From the foregoing it is readily apparent that I have provided a simple and rugged, drying apparatus which requires relatively little floor space for a given length of drying conveyor. The mechanism does not involve the use of complicated driving devices and is easy to maintain in service.

While I have described a preferred embodiment of my invention modifications will readily occur to those skilled in the art. For example, other air heating arrangements obviously may be employed. I do not, therefore, desire my invention to be limited to the particular construction illustrated.

What I claim and desire to secure by Letters Patent:

1. In apparatus for drying crushed minerals, and the like, an upright chamber and a series of conduits connected therewith; a series of elongated perforated conveyors mounted transversely within said chamber, each said conveyor being inclined from one end downwardly toward the other; means for supplying material to be dried to said one end; means for heating air and discharging said heated air through said conduits and into said chamber and toward each said conveyor through openings in said chamber adjacent the lower end of each said conveyor thereof; means for vibrating each said conveyor; and means for collecting dried material at the bottom of said chamber and affording removal of the material therefrom.

2. In apparatus for drying crushed minerals and the like, an upright chamber and a series of conduits connected therewith; a plurality of pairs of vertically spaced parallel flat elongated conveyors in said chamber, at least the upper conveyor of each pair having holes therein permitting at least some material to pass therethrough and said pairs being mounted in downwardly inclined zigzag arrangement; means for introducing material to be dried to said chamber at the upper end of the top one of said pairs of conveyors; means for directing streams of air at relatively high velocities through the spaces between the upper and lower conveyors of each pair; means for heating the air circulated through said shamber; means for agitating the material on said conveyors; and means for collecting dried material and affording removal thereof from said chamber.

3. In apparatus for drying crushed minerals and the like, an upright chamber and a series of conduits connected therewith, a plurality of pairs of vertically spaced parallel flat elongated conveyors in said chamber, at least the uppermost of each said pair being perforated, said pairs being mounted in downwardly inclined zigzag arrangement, means for introducing material to be dried to said chamber at the upper end of the top one of said pairs of conveyors, means for withdrawing air from said chamber and heating it and returning it to the chamber, said last mentioned means including air inlet nozzles at the lower end of each said pair of conveyors for directing the heated air between the two conveyors of each said pair and air outlets from said chamber at the upper ends of each of said pairs, and means for collecting the dried material and for affording removal of said material from said chamber.

4. In apparatus for drying crushed minerals and the like, an upright chamber; a plurality of elongated flat conveyors within said chamber and inclined downwardly in zigzag disposition, the inclination of successive ones of said conveyors being progressively less steep from the top toward the bottom of said chamber; means for conducting material to be dried to the upper end of the top one of said conveyors; means for vibrating said conveyors; means for heating air and discharging said heated air into said chamber through openings in the wall of said chamber adjacent the lower end of each of said conveyors; and means in the lower portion of said chamber for collecting dried material and for affording removal thereof from said chamber.

5. In apparatus for drying crushed minerals and the like, an upright chamber and a series of conduits connected therewith; a plurality of pairs of vertically spaced parallel flat elongated conveyors in said chamber, said pairs being mounted in downwardly inclined zigzag arrangement and each conveyor having holes therein permitting at least some material to pass therethrough with the holes being smaller in successively lower pairs of conveyors; means for introducing material to be dried to said chamber at the upper end of the top one of said pairs of conveyors; means for heating air and discharging said heated air through said conduits toward the material on said conveyors; means for agitating the material on said conveyors; and means for collecting dried material and for affording removal of the material from said chamber.

6. In apparatus for drying crushed minerals and the like, an upright chamber and a series of conduits connected therewith; a plurality of pairs of vertically spaced parallel flat elongated conveyors in said chamber, said pairs being mounted in downwardly inclined zigzag arrangement and each conveyor having holes therein permitting at least some material to pass therethrough with the holes being smaller in successively lower pairs of conveyors; means for introducing material to be dried to said chamber at the upper end of the top one of said pairs of conveyors; means for heating air and discharging said heated air through said conduit toward the material on said conveyors; means for agitating the material on said conveyors; and means for collecting dried material and for affording removal of the material from said chamber, said means including collecting hoppers of different sizes disposed in series beneath the lowermost conveyor with larger hoppers adjacent the ends of the lowermost conveyor.

7. In apparatus for drying crushed minerals and the like, an upright sealed chamber and two series of conduits connected therewith, one series of conduits being heated air supply conduits and the other series being air removal conduits; a plurality of pairs of vertically spaced, parallel flat elongated conveyors in said chamber, said conveyors having holes therein permitting at least some material to pass therethrough, with the holes in each pair of conveyors being larger than the holes in the next lower pair of conveyors, and said pairs being mounted in downwardly inclined zigzag arrangement; sealed means for introducing material to be dried to said chamber at the upper end of the top one of said pairs of conveyors; nozzles at the ends of said air supply conduits adjacent the lower end of each pair of

conveyors for directing streams of heated air at relatively high velocities through the spaces between the upper and lower conveyors of each pair, an air removal conduit being connected to said chamber adjacent the upper end of each pair of conveyors; a blower having an intake connected with said air removal conduits and an outlet connected with said air supply conduits; means for heating the air removed from said chamber; baffle means for removing dust from such air; means for removing moisture from such air; means for agitating the conveyors to agitate the material on said conveyors, said means being disposed principally exteriorly of said chamber and connected to said conveyors through flexible sealing diaphragms; and means for collecting dried material and affording removal thereof from said chamber.

8. Apparatus for drying granular material and the like comprising a chamber, a plurality of resiliently mounted elongated conveyors inclined downwardly in zig-zag relation within said chamber, an opening in said chamber adjacent one end of each of said conveyors, a flexible diaphragm having a hole therethrough mounted in each of said openings, a link extending through each of said holes and connected at one end to said one end of each of said conveyors, an eccentric operatively connected to the other end of each of said links, and means for blowing hot dry air through said chamber, said last-named means comprising inwardly directed nozzles extending into said chamber adjacent one end of each of said conveyors and an outlet extending out of said chamber adjacent the other end of each of said conveyors.

9. Apparatus for drying wet, crushed minerals and the like comprising a chamber, a plurality of elongated conveyors inclined downwardly in zig-zag relation within said chamber, each of said conveyors having perforated vertically spaced upper and lower plates; sharp pointed projections on the upper surfaces of said plates in staggered relation with respect to said perforations adapted to break up and prevent stratification of said minerals on said conveyor, means for vibrating said conveyors, and means for circulating hot, dry air between the upper and lower plates of each of said conveyors.

10. Apparatus for drying granular material comprising a drying chamber, a plurality of elongated conveyors inclined downwardly in zig-zag relation within said drying chamber, a plurality of inlet openings in said drying chamber, one of said inlet openings being located adjacent the lower end of each of said conveyors, a plurality of outlet openings in said drying chamber, one of said outlet openings being located adjacent the upper end of each of said conveyors, a blower mounted adjacent said drying chamber, a heating chamber connected to said blower, a plurality of baffles in said heating chamber forming tortuous air passages, adsorbent moisture removing means and heating means in said heating chamber, dust collecting means mounted on said heating chamber below said baffles, a duct leading from said blower to said inlet openings and a duct leading from said heating chamber to said outlet openings.

11. Apparatus as set out in claim 10 wherein said inlet openings are in the form of nozzles adapted to direct a high velocity jet of air toward the lower end of said conveyors.

12. Drying apparatus, comprising a chamber sealed from the atmosphere and having top, side and end walls, an open bottom closed by a plurality of hoppers arranged in series, a series of conveyors arranged in zig-zag formation in the chamber and supported for vibratory movement, each conveyor comprising upper and lower perforated decks, said perforations being graduated in size with the smaller perforations adjacent the bottom of said chamber, a circulatory system for discharging heated air adjacent the lower end of each said conveyor between its upper and lower decks, means in said system for heating the circulating air and removing dust and moisture therefrom, means for feeding a wet, granular material onto the upper end of the uppermost conveyor, means for vibrating each conveyor to induce a progressive movement of the material from its point of introduction to said hopper, one of said hoppers being positioned below the lower end of the lowermost conveyor to receive the larger pieces of material, and the others of said hoppers being positioned below the upper portion of said conveyor to receive the smaller pieces of material passing through said perforations.

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